ENERGY CONSERVATION

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GRANULATED FOAM GLASS CERAMIC — A PROMISING HEAT-INSULATING MATERIAL

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Environmentally safe, resource-conserving technology was developed for manufacturing thermal-insulating, granulated foam glass with closed pores. The heat-engineering characteristics of the granulated foam glass ceramic obtained allow recommending it as an effective thermal insulating material for high-temperature thermal units and residential networks.

Providing power to in civil buildings alone requires approximately 35% of all of the fuel produced in Russia. Using effective heat-insulating materials in buildings will reduce heat losses to 20%. The situation is no better in industry, where high-temperature technologies that take place in severe production conditions are used. Heat losses to the environment are 20 – 30%.

TomTekhnologiya Ltd. has developed a new heat-insulating material — granulated foam glass ceramic (PSK200) with high heat-insulating characteristics designed for insulating thermal units and engineering systems and structures. The novelty of the work consists of the use of organic additives and low-melting fillers with the simultaneous use of different kinds of glass (nonstandard cullet).

The rational composition of the batch that resulted in granules with the highest thermophysical parameters was determined experimentally.

Characteristics of PSK200 foam glass ceramic

Bulk density, kg/m^3	200 – 300
Thermal conductivity, W/(m · K)	0.060 – 0.085
Sound absorption coefficient, %, at 600 – 1200 Hz frequency	15 – 20
Compressive strength, MPa	0.8 – 3.0
Water absorption, vol.%	< 3.0
Temperature of use, °C	From – 200 to + 600

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Granules 5 – 12 mm in diameter were investigated in the experiments (Fig. 1).

When the low-melting filler content was changed from 10 to 18%,[2] the specific mass and as a consequence, the bulk density was changed from 200 to 300 kg/m^3 in the rational batch composition. The amount of glass was decreased in the rational composition by increasing the content of low-melting filler and organic additives. The foam glass ceramic with

[2] Here and below: mass content.

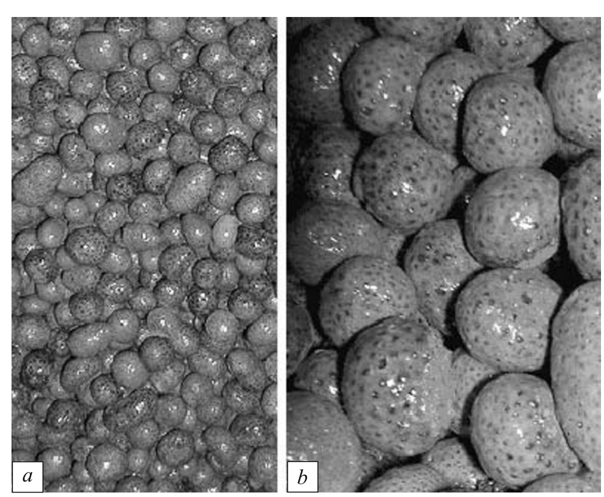

Fig. 1. PSK200 foam glass ceramic granules 5 – 7 mm (*a*) and 10 – 12 mm (*b*) in diameter.

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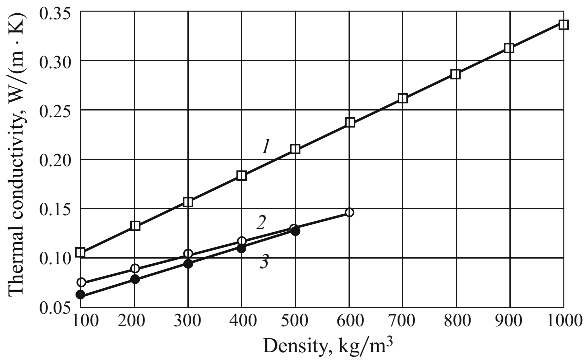

Fig. 2. Thermal conductivity of heat-insulating materials as a function of the density: *1*) diatomaceous crumb; *2*) foam glass ceramic; *3*) mineral wool.

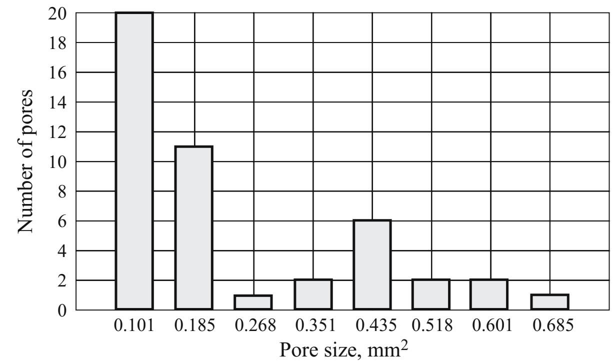

Fig. 3. Pore distribution in granules 10 – 12 mm in diameter.

these thermophysical characteristics obtained can be used as bulk heat-insulating material in construction and for heat-insulation of industrial furnace roofs and thermal power-engineering units. The technology makes it possible to obtain different geometric shapes — blocks, tiles, segments — from foam-glass ceramic granules.

Special attention was focused on the thermal-engineering characteristics of the granules in comparison to other heat-insulating materials used in industry in the experiments in [1].

The density is a function of the content of the low-melting filler and organic additive. As a function of the requirements imposed on the material in correspondence with the conditions of its use, the density can be adjusted by changing the content of the filler and organic additive. The dependence of the thermal conductivity of the granulated foam glass ceramic on the density was obtained experimentally. The curves of the thermal conductivity of PSK200 foam glass ceramic and heat-insulating materials used in construction and industry as a function of their density are shown in Fig. 2.

When 10% low-melting additive and 3% organic additive are added to the rational composition, a granule with a density of 200 kg/m^3 and thermal conductivity of 0.067 W/(m · K) is obtained. When the low-melting additive content increases, the thermal conductivity of the foam glass ceramic increases and when a density of 550 kg/m^3 is attained, it becomes the same as in diatomaceous grit. This makes it possible to use the foam glass ceramic in the heat insulation of high-temperature furnaces and power units and pipelines with higher efficiency.

The pore size and position over the section, wall thickness, and the glaze coat of the granules were investigated by optical microscopy (Fig. 3).

The pores were in the form of a honeycomb with glass walls. Closer to the surface, their size decreased, and the walls were saturated with carbon and the low-melting filler which formed the glaze coat on the surface of the granules. The compressive strength and bulk density of the granules were determined in accordance with GOST 9758.

As Fig. 4 shows, the mechanical strength of the foam glass ceramic granules was much higher than the strength of

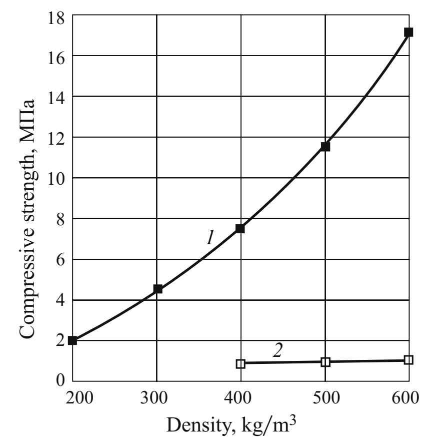

Fig. 4. Mechanical strength of heat-insulating materials as a function of density: *1*) foam glass ceramic; *2*) autoclave concrete.

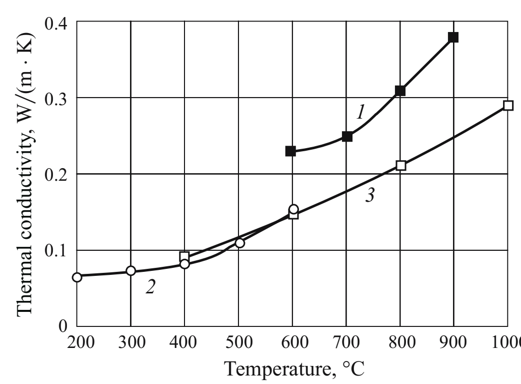

Fig. 5. Thermal conductivity of heat-insulating materials as a function of temperature: *1*) diatomaceous crumb; *2*) foam glass ceramic; *3*) autoclave concrete.

autoclave foam concrete. Note the important energy-conserving and construction advantages of granulated foam-glass ceramic relative to diatomaceous crumb, mineral wool, and foam concrete.

The thermal conductivity was also studied as a function of the temperature (Fig. 5) of the foam glass ceramic and ma-

terials widely used in construction and industry — diatomaceous crumb and autoclave foam concrete [2 – 4].

For the foam glass ceramic, the dependence was determined in [4] with Eq. (1) and with Eq. (2) for the diatomaceous crumb and foam concrete:

$$\lambda = 0.06 + 1.4 \times 10^{-4} t; \quad (1)$$

$$\lambda = 0.079 + 2.6 \times 10^{-4} t, \quad (2)$$

where λ is the thermal conductivity, W/(m · K); t is the temperature, °C.

At 600°C, the thermal conductivity of the foam glass ceramic was 0.144 W/(m · K) versus 0.235 W/(m · K) for diatomaceous grit. The data in Fig. 5 indicate the effectiveness of using the heat-insulating properties of the foam glass ceramic in the 200 – 600°C temperature range.

An environmentally safe, resource-conserving technology was thus developed for obtaining heat-insulating granulated foam glass with closed pores. Incorporation of surfactants makes it possible to use low-temperature technologies. Cullet can be used without preliminary sorting with respect to the chemical composition.

Granules with different characteristics for the mechanical strength, density, and thermal conductivity were obtained as a function of the rational composition of the batch, fineness of grinding, and temperature conditions. The characteristics of pore formation as a function of the fineness of grinding the batch and the initial annealing temperature and additive content were established.

The thermal-engineering characteristics of the granulated foam glass ceramic obtained allow recommending it as effective heat-insulating material for high-temperature thermal units and municipal networks.

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